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Status of Axisymmetic CFD of an Eleven Inch Diameter Hybrid Rocket Motor

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Current status of a steady state, axisymmetric analysis of an experimental 11" diameter hybrid rocket motor internal flow field is given. The objective of this effort is to develop a steady state axisymmetric model of the 11" hybrid rocket motor which can be used as a design and/or analytical tool. A test hardware description, modeling approach, and future plans are given. The analysis was performed with FDNS implementing several finite rate chemistry sets. A converged solution for a two equation and five species set on a 'fine' grid is shown.

Status of Axisymmetric CFD Analysis of an Eleven Inch Diameter Hybrid Rocket Motor

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Status of Axisymmetric CFD Analysis of an Eleven Inch Diameter Hybrid Rocket Motor

- OBJECTIVE
- BACKGROUND
- APPROACH
- STATUS
- FUTURE PLANS

OBJECTIVE

- Develop a steady state axisymmetric model of 11" hybrid rocket motor which can be used as a design and analytical tool.

BACKGROUND

- 11" Hybrid Rocket Motor - solid fuel, gaseous oxidizer
  - fuel
    - solid grain 60% HTPB, 40 % escorez
    - initially at ambient temperature
  - oxidizer
    - GOX injected at ambient temperature
    - pressures of 300 to 1000 psig
  - geometry
    - 11 inch diameter casing, various port designs
    - total fuel grain length varies, 34, 68 or 102 inches

- 20 tests have been conducted with various configurations
  - Modeling test # 2 conditions
    - GOX injection pressure = 300 psi, flow rate = 6.8 lbm/s
    - GOX injected through 12 radial ports
    - overall o/f = 3.04
    - run duration 9.5 seconds
    - nozzle area ratio of 1.56

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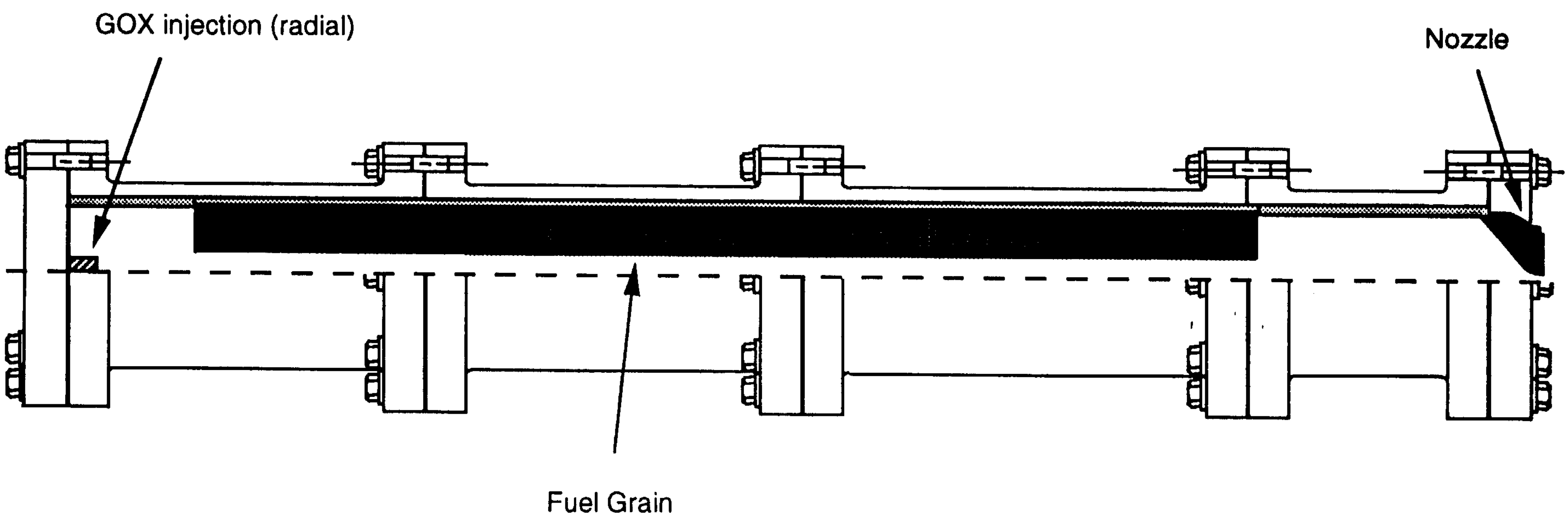
Cross Section of 11" Hybrid Rocket Motor



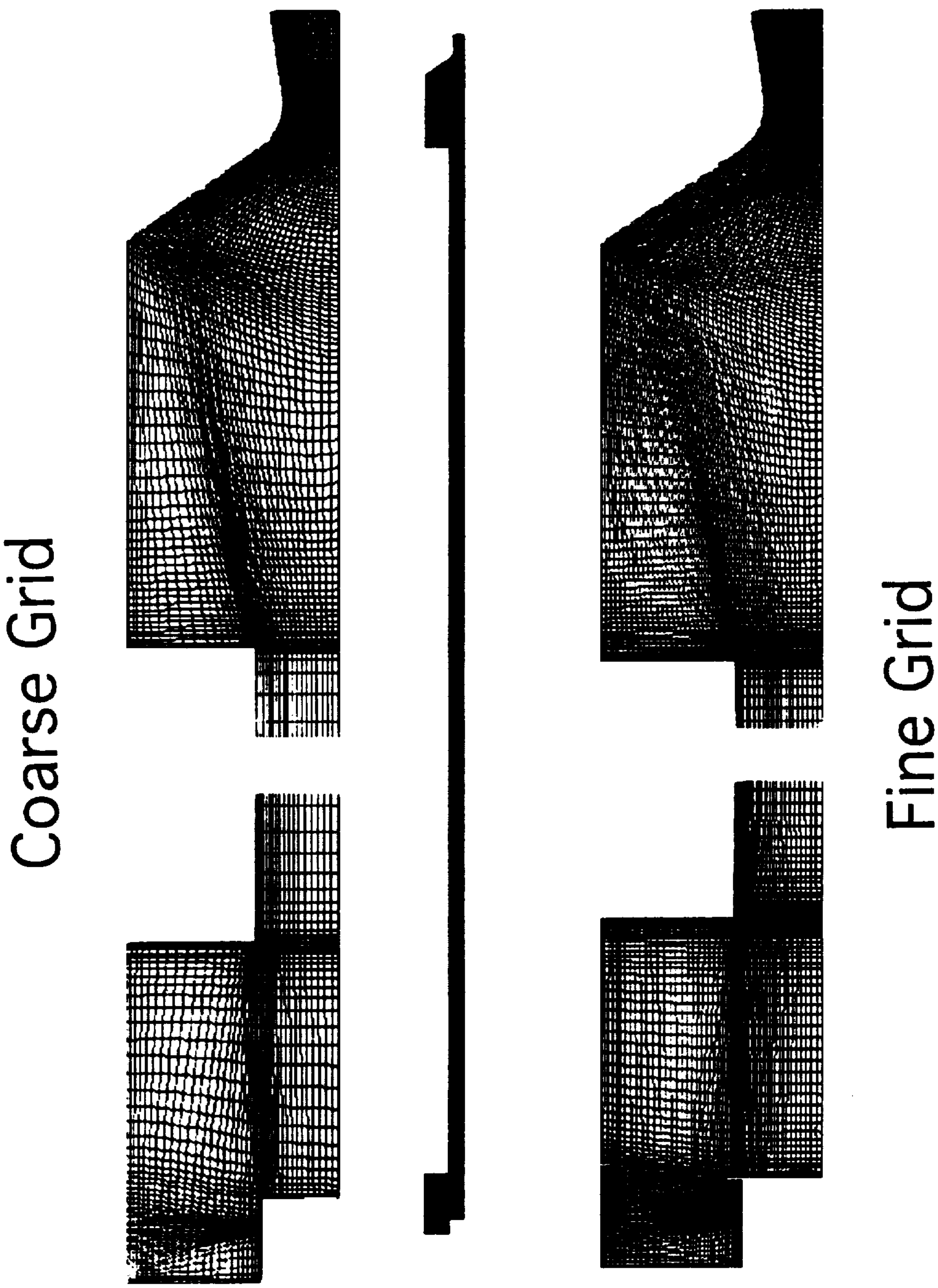
APPROACH

- Axisymmetric, three zone model
  - steady state, early in test
  - GOX injection ports modeled as equivalent area circumferential slot
    300 psia, flow rate=6.8 lbm/s, temperature=517 deg R
  - fuel grain modeled as blowing wall, uniform sublimation rate
    flow rate=2.27 lbm/s, temperature=1458 deg R

- Two grids implemented
  - 9800 and 21600 points

- Solution Procedure
  - begin with cold GOX, hot fuel, w/o reaction, subsonic flow
  - turn on chemistry, supersonic exit

- Six chemistry models tried
  - 5 species, 2 equations up to 11 species, 17 equations


Coarse Grid
Fine Grid

STATUS

- Converged solutions obtained on both grids, grid dependent

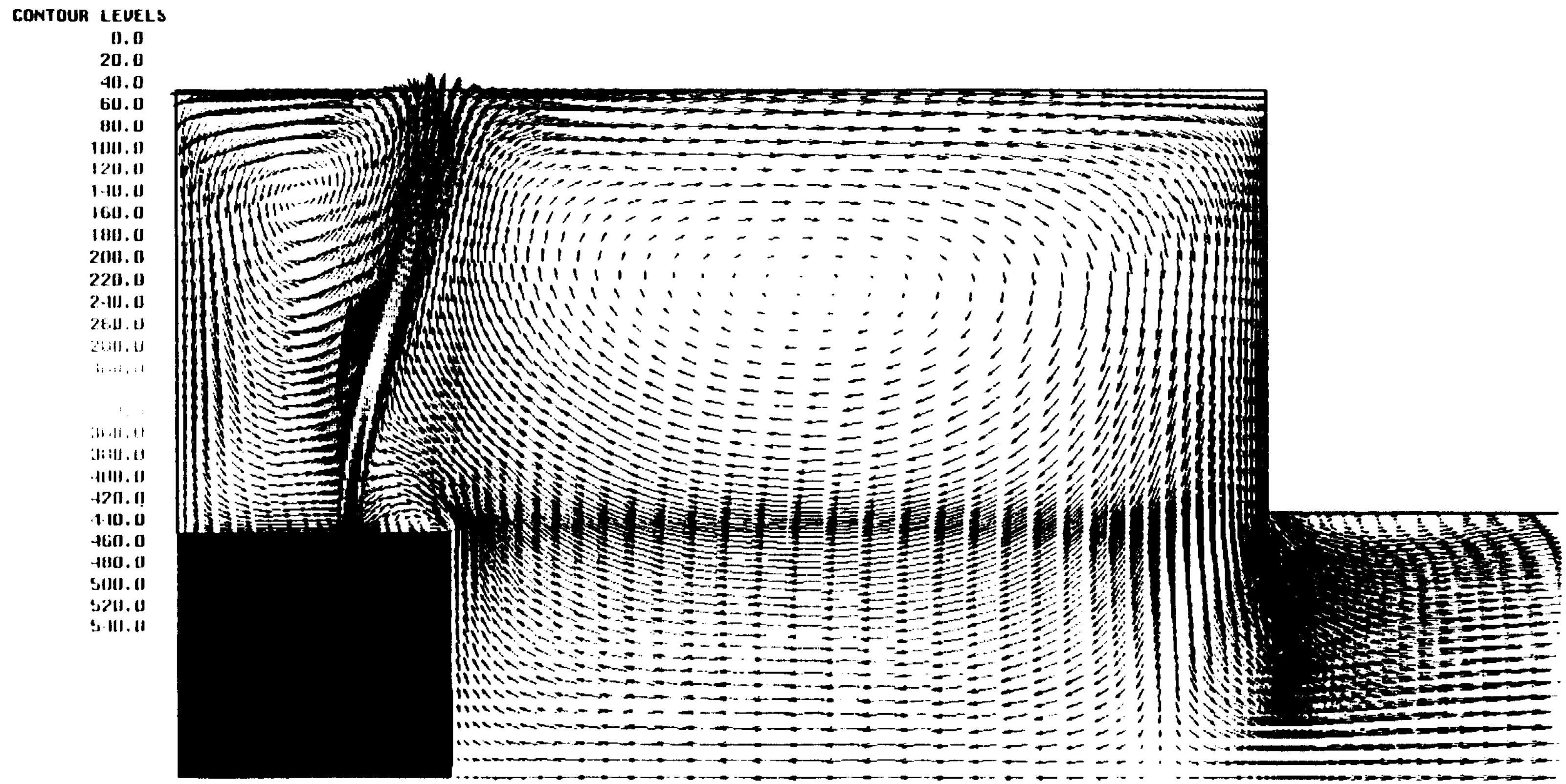
- Flow field appears reasonable
  - mass balanced solutions
  - some zone interface effects at zone 1 and 2 boundary

- Temperature is too high, but trends appear correct

VELOCITY COLORED BY VELOCITY MAGNITUDE

Forward Mixing Chamber

(ft/s)



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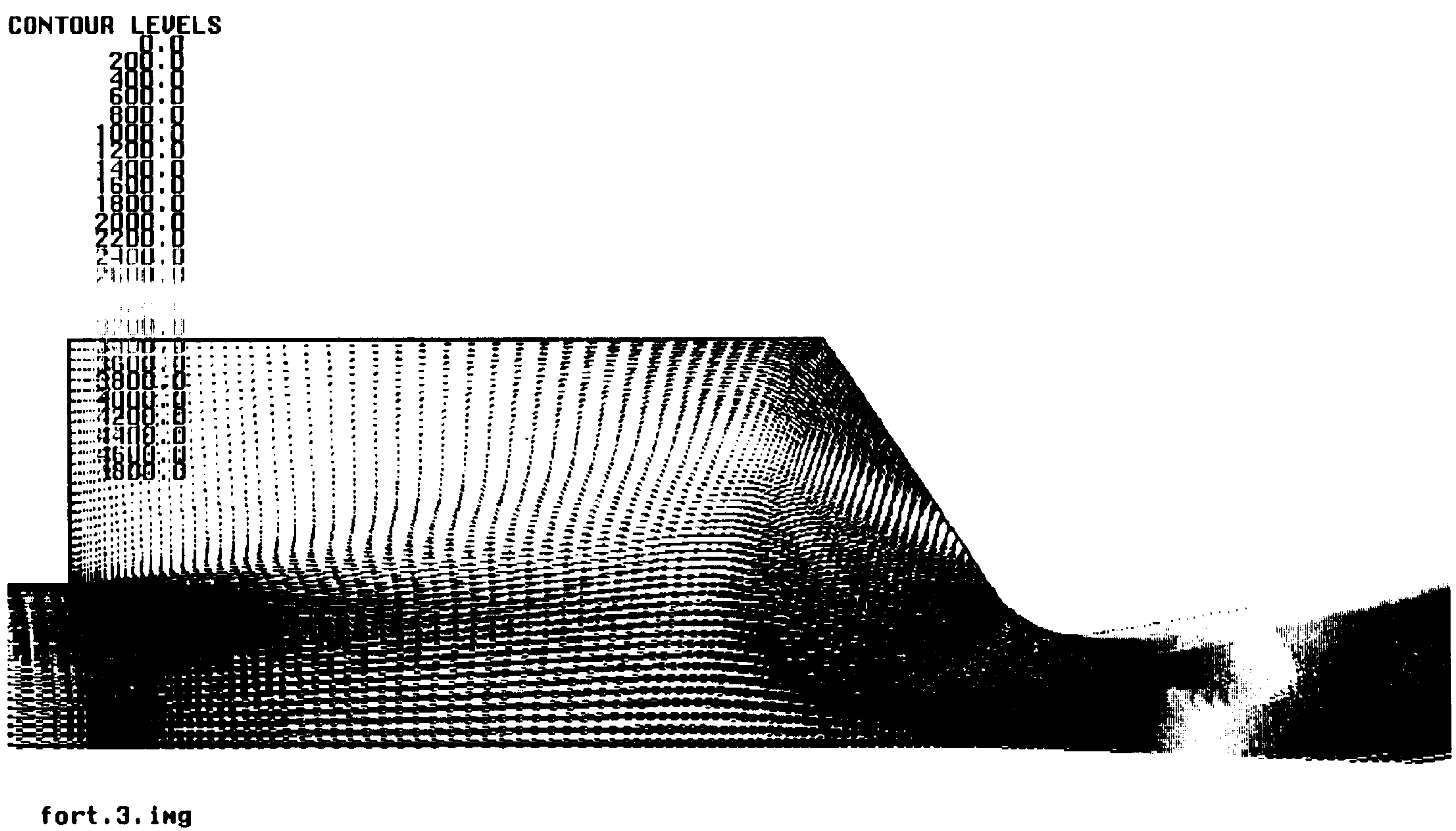
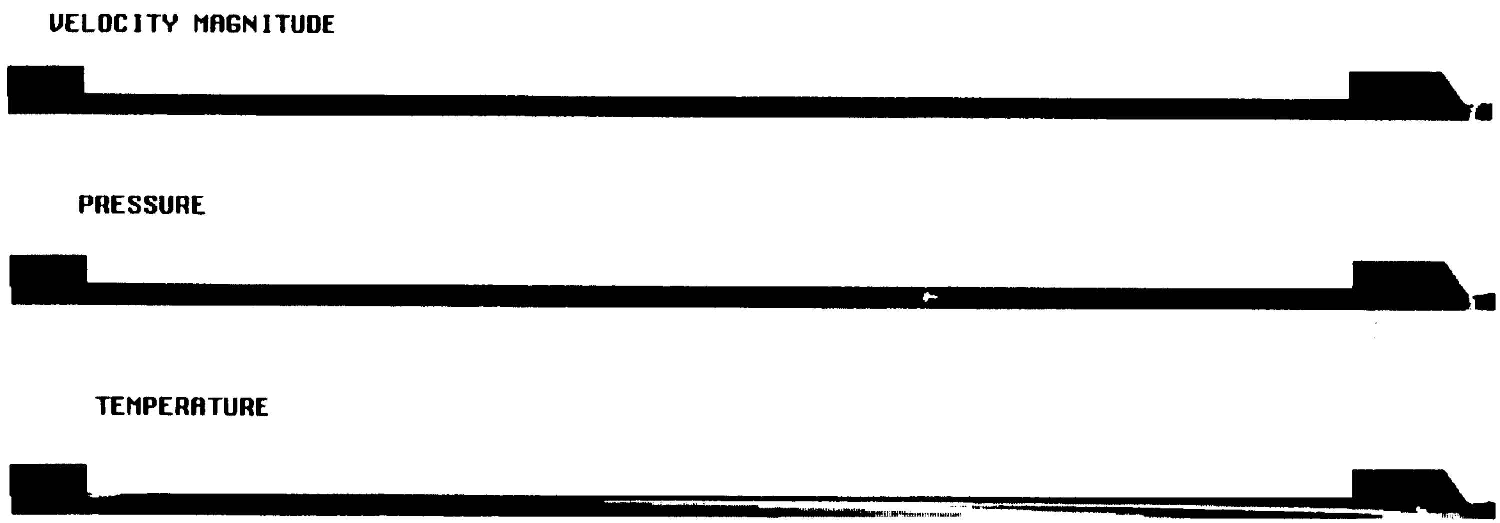
VELOCITY COLORED BY VELOCITY MAGNITUDE
Aft Mixing Chamber
(ft/s)

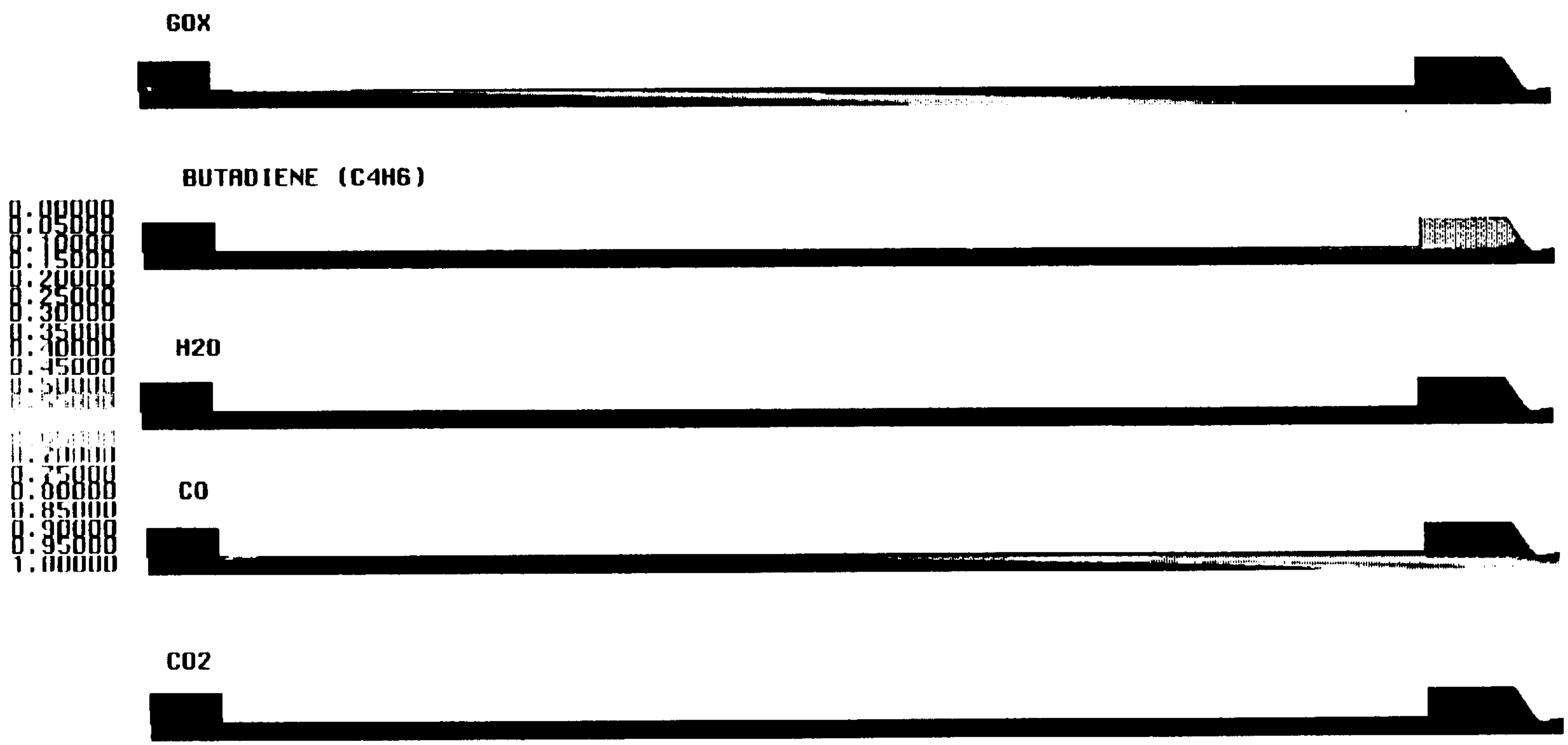


Fine Grid Results



Fine Grid Results

Mass Factions for a Two Equation Finite Rate Model



FUTURE PLANS

- determine 'best' chemistry model
- obtain a grid independent solution
- implement variable fuel sublimation rate in axial direction
- match limited test data